



## Original Communication

## Brain weight of Iranian population; the first report

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## ABSTRACT

**Objective:** Knowledge of the normal range of brain weight is a useful parameter in diagnosis of many pathological conditions. There are racial differences as well as other variables in any population affecting the brain weight. We conducted this study to determine the brain weight in healthy adult Iranian population among both sexes in order to formulate a standard reference range taking into account the variables of age, sex, weight, BMI and height.

**Materials & methods:** Prospective analysis of data from 1308 forensic autopsies of Iranian adults from 23 June 2008 to 22 June 2009 was performed. All subjects were Iranian adults dying of short survival injury time (<15 min) from unnatural deaths who showed no pathological changes.

**Results:** Brain weight, body weight, body height and BMI were evaluated in 1143 subjects, including 856 males and 287 females, ranging 16–88 years old. Brain weight in males and females was  $1322.45 \pm 117.05$  and  $1219.03 \pm 127.85$  gm respectively ( $P = 0.001$ ). A negative significant correlation between age and brain weight was seen in both sexes ( $P = 0.001$ ). Moreover, there was a positive significant correlation between body height and Brain weight in males and females ( $P = 0.001$ ).

**Conclusions:** The study indicated higher values in males than females. The observed correlation of brain weight with age, weight and body height was more prominent in females. The results revealed that body height and age in males and body height, weight and age in females may play a predictive role in estimation of brain weight.

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## 1. Introduction

At an autopsy, the weight of organs is very important for pathologist to examine whether they showed pathological changes. One of the most important organs is the brain, since it is the organ of mind and its weight is given a considerable attention by anthropologist and anatomist. It was found by previous works that some diseases can affect the brain weight. For example it was found that a decrease in brain weight occurs in schizophrenia, Down syndrome, Alzheimer disease, Parkinson disease,<sup>1–4</sup> also it was previously revealed that brain weight in alcohol dependent males is significantly less than normal population.<sup>5</sup>

In addition other authors found that intelligence may be affected by brain size and brain weight.<sup>6</sup> Furthermore new researches showed that the brain size and general mental ability are correlated with age, socioeconomic position, sex, and ancestral population groups.<sup>7</sup>

It is obvious that knowing the normal brain weight is necessary for any population to distinguish diseases as mentioned above. It must be noted that brain weight is dependent on environmental and socioeconomic conditions which are quite different among countries, even different in various part of a country.<sup>8–10</sup>

Data analysis of 250 autopsies in Thailand from 2003 to 2005 showed that the mean brain weight in males and females was  $1339 \pm 160$  and  $1165 \pm 184$  gm respectively.<sup>11</sup> Data from 269 males and 230 females (aging between 15 and 60 years) in another study in Thailand during 2000–2005 indicated that average brain weight in males was 1311 gm and in females was 1170 gm.<sup>12</sup> Recent published data from Thailand, included 561 autopsies, showed that mean brain weight in males and females was  $1330 \pm 127$  and

Abbreviations: LMO, Legal Medicine Organization; BMI, Body Mass Index; BW, Body weight; BH, Body height; BL, Length.

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**Table 1**

Age, body height, body weight, BMI and brain weight of males and females.

Groups variables	Male (n = 856)	Female (n = 287)	P Value
	Mean $\pm$ SD (range)	Mean $\pm$ SD (range)	
Age (year)	43.71 $\pm$ 17.82 (16–88)	44.89 $\pm$ 19.95 (16–88)	0.34
Body height (cm)	172.68 $\pm$ 5.62 (151–190)	160.4 $\pm$ 5.52 (141–175)	0.001
Body weight (Kg)	74.26 $\pm$ 10.7 (40–110)	66.7 $\pm$ 10.83 (45–95)	0.001
BMI (kg m <sup>-2</sup> )	24.86 $\pm$ 3.09 (16.07–38.56)	26.03 $\pm$ 4.18 (19.53–36.32)	0.001
Brain weight (gm)	1322.45 $\pm$ 117.05 (920–1714)	1219.03 $\pm$ 127.85 (885–1697)	0.001

1208  $\pm$  131 gm respectively.<sup>13</sup> Jit has shown that the adult brain weight of northwest Indian males was 1297  $\pm$  102 gm and that of females was 1194  $\pm$  93 gm.<sup>14</sup> Another report from northwest Indian children and adolescents (1–17 years) showed that the mean brain weight in males and females was 1251  $\pm$  124 and 1152  $\pm$  124 gm respectively.<sup>15</sup>

Results of a literature review indicated that reported weights of many of the Indian internal organs, including brain, were considerably less than their Japanese counterparts.<sup>16</sup> According to this article, mean brain weight of Indian males and females was 1255 and 1220 gm; comparing with Japanese (1402 and 1288 gm respectively).<sup>16</sup> Sawabe et al had determined standard organ weights among 1615 consecutive autopsy cases of patients aged 60–99 years who died between 1995 and 2003, and cases of 50 centenarians who died between 1973 and 2005 in Japan. Their results showed that mean brain weight among males and females was 1275  $\pm$  116.1 and 1140  $\pm$  113 gm respectively.<sup>17</sup> Moreover, data from 8000 autopsies of male and female patients without brain diseases in Germany showed that the average brain weight of the adult males was 1336 gm and that for the adult females being 1198 gm.<sup>18</sup> A retrospective review of post-mortem reports in 100 suicide victims and 100 age/gender-matched controls who died accidentally or of natural causes in Manchester (UK) showed that average brain weight in suicide cases was 1449  $\pm$  161 gm (1468 gm for males and 1251 gm for females) compared with 1423  $\pm$  161 gm in the control group (1449 gm for males and 1322 gm for females).<sup>19</sup>

It should be mentioned that the brain weight reported from other countries is obviously not acceptable for Iranian adult population. As literature available on the brain weight of the Iranian population is limited,<sup>20</sup> the objective of the present study was to provide such information to formulate a standard reference range of brain weight, taking into account the variables of age, sex, weight, BMI and height.

## 2. Materials & methods

Following the approval of survey from medical ethic committee, we designed a prospective analytical descriptive study to evaluate Iranian brain weight and its relation to Body Weight (BW), Body Length (BL), Body Mass Index (BMI), gender and age.

The study was conducted within the framework of the Tehran's Legal Medicine Organization (LMO), the largest Iran's LMO that

serves about 20% of the Iran's population. The population of the Tehran city in the center of Iran is more than 8,000,000, mostly from middle socioeconomic level. The Tehran's LMO investigates all unnatural and suspicious deaths and does more than 10,000 autopsies annually.<sup>20–26</sup>

We analyzed 1308 forensic autopsies of Iranian adults (age > 15 years) from 23 June 2008 to 22 June 2009. The BW, BL and the Brain weight were collected from post-mortem records. Included criteria comprised all subjects who were Iranian adults dying of short survival injury time (<15 min) from unnatural deaths. Excluding criteria were: 1) natural death 2) unnatural deaths being treated 3) macroscopic evidence of disease or histological abnormality 4) decomposition 5) fire related death 6) time of death > 24 h 7) destroy or loss of all or part of brain by the cause of death such as car accident or from a fall.

Most of the subjects were from accidental death, suicidal death or criminal death. Under supervision of a forensic pathologist responsible for the autopsy, weight and the height of the body were measured by the mortuary technicians. The body length measured was the head to heel length. All the bodies were weighed unclothed with the same weighing machine (300 kg range, 100 gm intervals). The brain was weighed, unfixed at the time of removal from the cranium with the same electronic weighing machine having the accuracy of  $\pm 0.1$  gm. The electronic weighing machines being used were of the same type (3000 gm range, 0.1 gm intervals). They were daily calibrated before the beginning of autopsy with a reference weight of 1 kg. They were reset before each weighing during autopsy.

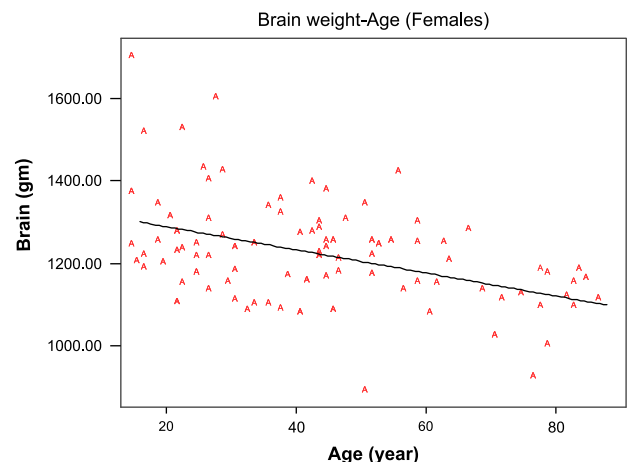
Body mass index (BMI), defined as weight (kg)/height<sup>2</sup> (m<sup>2</sup>) was calculated.

The data were analyzed by Statistical Product and Service Solutions (SPSS) software (Version 15; Chicago, Illinois, USA) using stepwise regression, Pearson correlation coefficient and Student's *t*-test. *P*-values  $\leq 0.05$  were considered as the statistically significant Levels.

**Table 2**

Correlation between brain weight and age, body height, body weight and BMI.

Groups variables	Male		Female	
	r	P Value	r	P Value
Brain weight-age	–0.219	0.001	–0.44	0.001
Brain weight-body height	0.144	0.001	0.41	0.001
Brain weight-body weight	0.069	0.043	0.21	0.001
Brain weight-BMI	0.011	0.759	0.40	0.50

**Fig. 1.** Relation between brain weight and age in females.

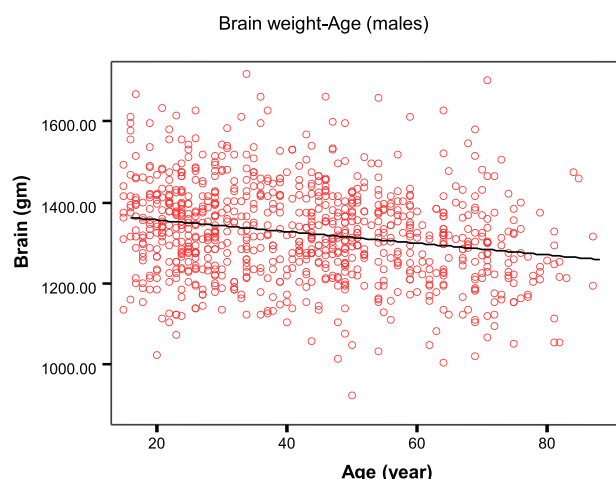


Fig. 2. Relation between brain weight and age in males.

Subjects were divided into gender of male/female with Body weight, Body height, BMI and brain weight for analyzing mean, standard deviation, maximum, and minimum. The results were plotted in a graph form to find the trend and predict the relationship of two Variables. After that, Pearson's correlation coefficient would be used to analyze the relationship between body weight and Brain weight, Height and Brain weight, BMI and brain weight, age and brain weight. Stepwise regression was performed between the weight of Brain (dependent variable) and body weight, body height, BMI and age (independent variables) of males and females.

### 3. Results

From the total of 1308 autopsies, 1143 were included in this study; 856 males and 287 females. The consideration variables in the present study were age, Body weight, Body Height, Body mass index (BMI), and Brain weight.

Mean of age, Body weight, BMI and Brain weight of males and females are shown in Table 1 (Table 1). The range of age in present study was 16–88; there was no significant correlation between males and females according to age. There was significant correlation between height ( $p = 0.001$ ), Body weight ( $p < 0.0001$ ) and BMI ( $p < 0.0001$ ) in males and females. Brain weight in males and females was  $1322.45 \pm 117.05$  gm and  $1219.03 \pm 127.85$  gm respectively, which was statistically significant. ( $p = 0.001$ ).

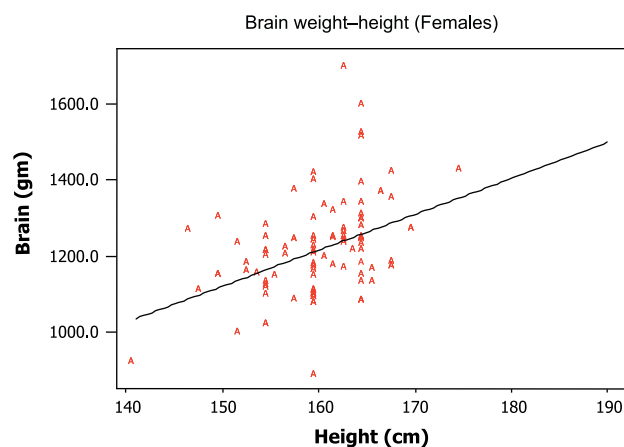


Fig. 3. Relation between brain weight and body height in females.

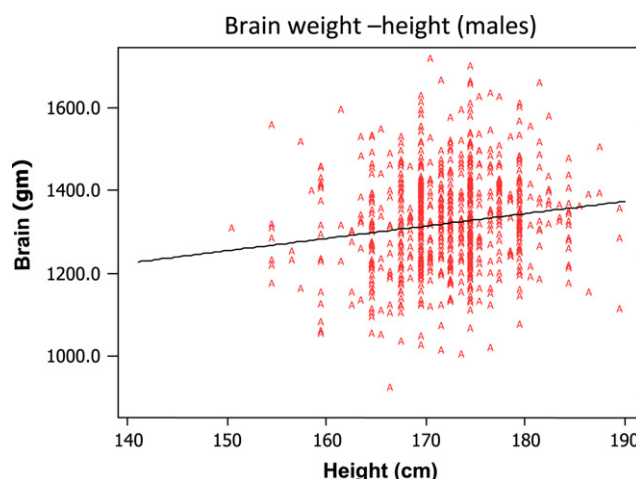


Fig. 4. Relation between brain weight and body height in males.

Table 2 shows the relation of brain weight with age, body height, body weight, and BMI in males and females (Table 2). There was a negative significant correlation between age and brain weight in both males and females. Figs. 1 and 2 show that, this negative relation is more powerful in females (Figs. 1 and 2). There is a positive significant correlation between body height and brain weight in males and females (Table 2, Figs. 3 and 4). Also there is a positive significant correlation between body weight and brain weight in males and females (Table 2, Figs. 5 and 6), but there was no significant correlation between brain weight and BMI in both females and males (Table 2, Figs. 7 and 8).

Table 3 shows the regression equation between the weight of brain (dependent variable) and body weight, body height, BMI and age (independent variables) of males and females (Table 3). The results revealed the variables of body height and age in males and body height, BMI and age in females included in regression equation as predictor variables.

Fig. 9 shows the mean brain weight in various age groups in males and females; also in this figure brain is at maximum weight in age of 15–20 years in both males and females (Fig. 9).

Fig. 10 shows the mean brain weight in various heights in males and females, it shows that in height of 180–185 cm in males and 170–175 cm in females the weight of brain is at maximum level (Fig. 10).

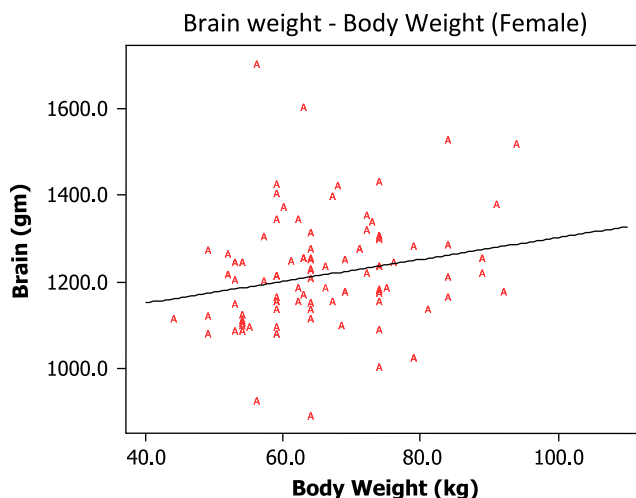


Fig. 5. Relation between brain weight and body weight in females.

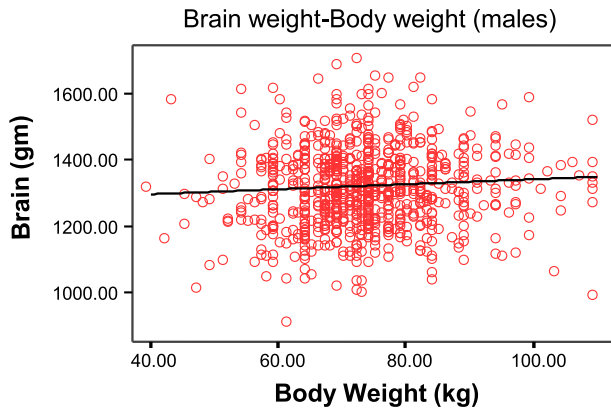


Fig. 6. Relation between brain weight and body weight in males.

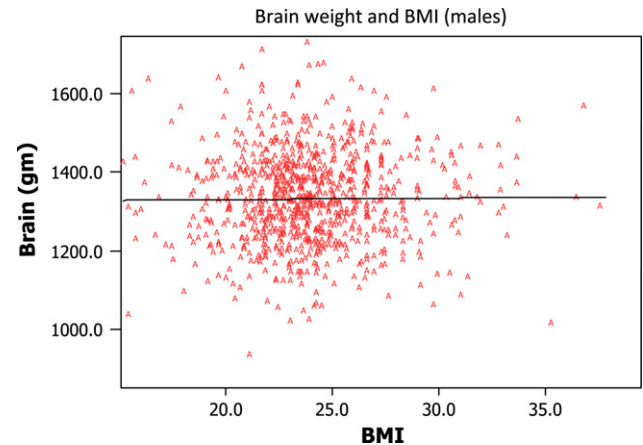


Fig. 8. Relation between brain weight and BMI in males.

Fig. 11 shows the mean brain weight in various body weights in males and females, and in the weight of 90–100 kg, weight of brain is at maximum level in both males and females (Fig. 11).

#### 4. Discussion

One of the means to detect the pathological conditions is body organ weight which is used commonly by forensic pathologists during an autopsy. This helps them to interpret the cause of death and find out the connection between trauma and disease.<sup>8–10,20,27</sup> The increase or decrease of internal organ weight compared to body weight and length is well recognized in many diseases.<sup>11</sup>

To our knowledge, this is the first report on the normal values of brain weights among Iranian autopsy patients who died from external causes. Although there are some reports about body organ weights, the big sample of adult fresh cadavers in this study and the need to have new data from any population implies the necessity of such study.

Regarding the results of this study, the mean weight of male's brain was  $1322.45 \pm 117.05$  gm and females' was  $1219.03 \pm 127.85$  gm. Data from magnetic resonance imaging volumetric analysis of the brain in healthy 20-year old Koreans showed that the volumes of the whole brain in male participants was significantly larger than those in female participants.<sup>28</sup> On the other hand, Nooranipour and Farahani used linear dimensions of the head measured with spreading caliper

and auricular head spanner for estimating brain weight in 772 normal 18–22- year old (320 males, 452 females) Iranians from different socioeconomic groups.<sup>29</sup> They showed that neurocranial volume and weight of males ( $1343.45 \pm 102.37$  cm<sup>3</sup> and  $1390.47 \pm 105.95$  gm, respectively) were higher than those in females ( $1163.02 \pm 115.76$  cm<sup>3</sup> and  $1203.73 \pm 119.81$  gm, respectively).<sup>29</sup>

Comparing with the literature, it seems that brain weight in Iranians is similar to the data from Thailand and Germany<sup>11–13,18</sup>; but according to the data from India, brain weight in Iranian males is more than Indians.<sup>16</sup> Data from the Japanese shows that mean brain weight in both genders is less than that of Iranians.<sup>17</sup> On the other hand, brain weight in England population is more than our findings (See Table 4).<sup>19</sup>

A significant negative correlation was found between age and brain weight in both males and females in this study. Previously, it was showed that there is a clear trend toward lower brain weight in aged persons, although different studies observed this decline within different age intervals.<sup>6,30</sup> There is a marked atrophy with loss of weight in elderly, because of age related physiological and pathological conditions, although the mechanism of senile atrophy is not clear yet.<sup>17,31</sup> Overall, it is stated that brains of 70- to 80-year olds, weigh about 7% less than the brains of 20-year olds.<sup>30</sup> The observed negative correlation between brain weight and age in this study was mild, consistent with Sawabe et al findings among Japanese.<sup>17</sup> This negative correlation was more prominent in females than males. The maximum brain weight was seen in the age of 15–20 years in both sexes. According to Svennerholm et al findings which investigated the brain weight from 184 Swedes individuals 20–100 years of age, the maximum data was found in 20–39 years in both males ( $1595 \pm 139$  gm) and females ( $1365 \pm 109$  gm).<sup>32</sup> The Mean of brain weights during two 10-year periods (20–30 years and 70–80 years of age) in 12 different studies from Scandinavian countries is summarized by Svennerholm et al.<sup>32</sup> The highest brain weights, particularly in the youngest age group (20–39 years), have been found by these

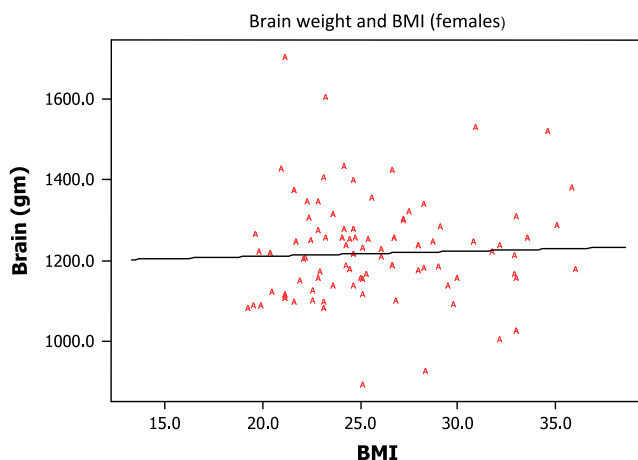


Fig. 7. Relation between brain weight and BMI in females.

Table 3

Regression equation of the relationship between Brain weight with independent variables of males and females.

Sex	Regression equation	R <sup>2</sup>
Male	Brain weight = $1013.74 + 2.116(\text{Height}) - 1.297(\text{Age})$	0.058
Female	Brain weight = $371.08 + 5.166(\text{Height}) + 1.728(\text{Weight}) - 2.14(\text{Age})$	0.270

Units: Brain weight = gram, Body Weight = kilogram, Body Height = centimeter, age = year.

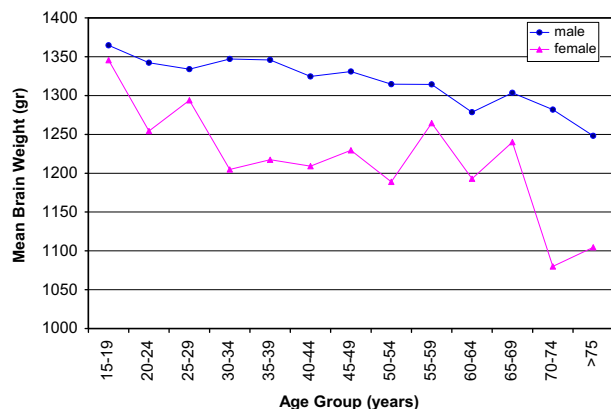


Fig. 9. Mean brain weight in various age groups in males and females.

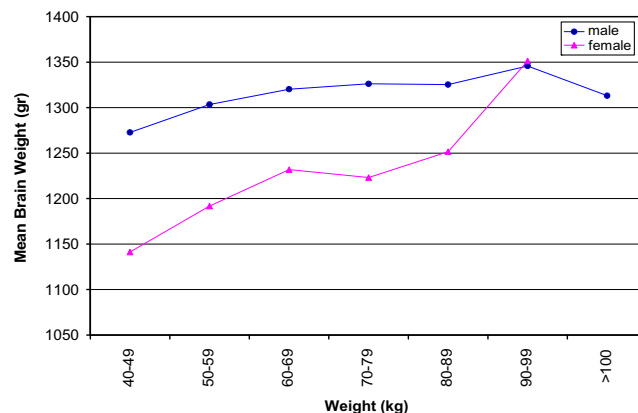


Fig. 11. Mean brain weight in various body weights in males and females.

authors.<sup>32</sup> Comparing with these results, in the present study brain weight in young males (15–20 years) was  $1364.68 \pm 123.70$  gm and in young females was  $1345.55 \pm 180.43$  gm. The lowest brain weight was seen in male individuals with 75 years and above ( $1248.11 \pm 98.64$  gm) and in females with 70–74 years ( $1080 \pm 52.28$  gm). According to these findings, weight brain in males showed an 8.54% decline from 15-year olds to 80-years olds. The observed brain weight decline percentage in females was 19.73%.

There was a significant positive correlation between body height and brain weight, the same for body weight and brain weight, in both genders. However, there was not any significant correlation between BMI and brain weight. In a Thai population, Mathuramon et al could not show any relation between brain weight and body weight and length of females, but there was a relation in males.<sup>13</sup> The same results were found in another earlier report from Thailand.<sup>11</sup> From the study of Koh et al on sixty healthy 20-year-old Koreans, the whole brain volume was correlated with body height in males but not in female participants.<sup>27</sup> On the other hand, according to Witelson study, brain size was minimally correlated with body height, with height accounting for 1–4% of the variance within each sex.<sup>6</sup> A stronger correlation between body height and brain weight than that between BMI and brain weight was seen among elderly Japanese.<sup>17</sup> The observed correlation of body height and body weight with brain weight was more prominent in females than males, a finding that is somehow unique in the literature.

In this study, the maximum brain weight was seen in males with body height 180–184 cm and females with body height 170–174 cm. Although in females the maximum body height was 174 cm, and we did not have cases more than 174 cm to compare with brain weight. The lowest brain weight (920 gm) was seen in >75 years old females with body height of 140–144 cm and body weight of 50–60 kg. Moreover, comparing body weight and brain weight, the highest brain weight was seen among those persons weighing 90–100 kg. Similarly there was not any female weighing more than 100 kg, to assure this finding.

Cephalometry, in which the dimensions of the head and face are measured, is useful in pediatrics, forensic medicine, plastic surgery, oral surgery, orthodontics and diagnostic comprehension between patient and normal populations.<sup>29</sup> A gold standard method for this purpose may be data driven from autopsy studies as real volumes and weights are measured.

Considering the importance of acquiring information on brain weight, this study was done to formulate a standard reference range of brain weight in Iranian population. The results revealed that body height and age in males and body height, body weight and age in females are predictor variables in regression equation. This equation can predict correctly the brain weight in females, using body height, body weight and age, in more than 27% and in males, using body height and age in more than 5%. There should be more research to find other effective variables in predicting brain weight of human.

Legal Medicine Organization of Iran with more than 1.5 million clinical forensic referrals and 50,000 autopsies per year is an appropriate field for such researches and trainings.<sup>20–26,33–40</sup>

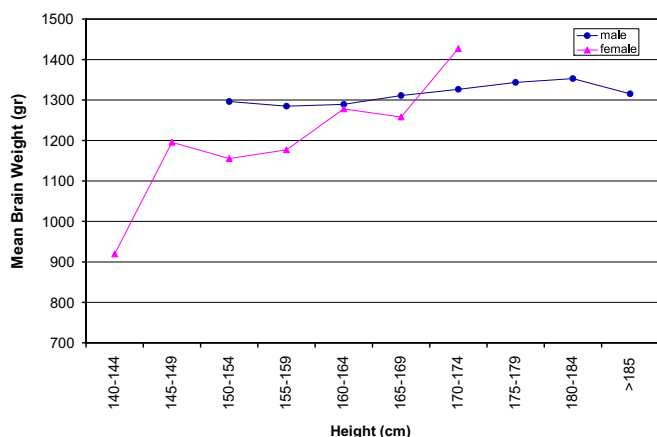


Fig. 10. Mean brain weight in various body heights in males and females.

Table 4

Comparison of different brain weights in several adult populations that were down in the various studies.

Mean of brain weight in different adult populations (gram)	Male	Female
Thai population (Chirachariyavej et al study)	1339	1165
Thai population (Narongchai and Narongchai study)	1311	1170
Thai population (Mathuramon et al study)	1330	1208
Northwest Indian population (Jit study)	1297	1194
Indian population (Spencer study)	1255	1220
Japanese cases of 50 centenarians (Sawabe et al study)	1275	1140
German population (Hartmann et al study)	1336	1198
UK population (Hamilton and McMahon study)	1449	1322
Iranian Population (Nooranipour and Farahani study)	1390	1204
Iranian Population (Sheikhazadi et al study)	1322	1209
Iranian Population (Our study)	1322	1219



## Conflict of interests

We have no competing interests.

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## Ethical approval

Written informed consent was obtained from the bereaved family of every patient prior to the autopsy examination. The ethical consideration was approved by the Ethics Committee of the Research Deputy of Iran's Legal Medicine Organization.

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